Face Perception: Broken into Parts

A recent study has shown that, using transcranial magnetic stimulation to stimulate an area of the visual cortex, the perception of face parts can be selectively and reversibly disrupted, while the perception of their arrangement is spared.

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Upon meeting a stranger on an airplane, the student of face perception will find it easy to engage a fellow traveller's interest in her area of research — the human face is of deep, inherent interest to all of us. We gaze at faces from birth; we watch faces closely during conversation, alert to cues about intention, honesty and potential romantic interest; we groom carefully to maintain and modify our facial appearance; we accept photographic images of the face as proof of identity; and we honour the famous and the infamous by capturing their faces in paintings, busts, postage stamps, tee shirts and mountain-sized carvings. This focus on faces is all for a good reason — the face carries a wealth of valuable information about the other people around us.

The significance of the face has not been missed by neuroscientists. As is often the case, the way was led by neurological observations of patients with brain damage. While there are hints from the 19th century and even back to classical times, the syndrome of prosopagnosia — the selective inability to correctly perceive faces visually — was formally identified about 60 years ago [1]. Since then, many strands of research have converged on the notion that face perception is an independent cognitive faculty, underpinned by specialised neural systems [2]. Landmarks in this research include: the dissociation of face perception from object recognition in neuropsychological patients [3]; the finding that some individuals exhibit a 'developmental', and partly heritable, prosopagnosia without any evident brain damage [4]; the discovery of single neurons in the temporal lobe of the macaque that respond strongly to faces [5]; and the observation of face-specific patterns in the electrical signatures of brain activity measured at the scalp [6].

In the last decade, however, the most intense focus has been on functional magnetic resonance imaging (fMRI) studies of face perception. These have identified three discrete brain areas that respond strongly to faces (depicted in various ways and under various tasks) and weakly to other objects and other visual stimuli (Figure 1). The occipital face area [7] and the fusiform face area [8] lie on the ventral surface of the brain, at the base of the occipital and temporal lobes, respectively. The third area is a portion of the superior temporal sulcus — a long fold along the lateral aspect of the temporal lobe — that responds particularly well to moving faces [9].

What has largely been missing from the toolbox is a way to selectively and reversibly disrupt, in healthy human volunteers, the function of specific brain regions thought to be involved in the analysis of faces. Now, Pitcher *et al.* [10] have reported in *Current Biology* how it is possible to interrupt, with a fine degree of spatial and temporal control, the flow of neural activity that makes sense of faces. The authors used transcranial magnetic stimulation (TMS) to disrupt the function of neurons in the occipital face area of healthy volunteers. Briefly, TMS works via the placement of a wire coil over the scalp. A brief, powerful electrical current is delivered through the coil. By induction, this creates an orthogonal magnetic field, which in turn induces an electric current in the neurons underlying the centre of the coil. The effect of this has been compared to a 'virtual' (and temporary) brain lesion [11].

Pitcher *et al.* [10] elegantly demonstrate just how fine-edged a tool this is. Volunteers were shown pairs of faces — a 'match' face, followed after a brief interval by a 'target' face — and asked to compare them. In the first experiment, accuracy was reduced when TMS stimulation was delivered over the right occipital face area, in a brief burst immediately following the target face. The impairment was specific to making decisions about the appearance of face parts ("are those the same eyes that I just saw?"), rather than about the arrangements of those parts ("are those eyes closer together than they were?"). The deficit did not occur in a similar task involving houses, nor did it occur when the left occipital face area was stimulated. (Many studies indicate a stronger right-hemisphere role in face perception.)

A second experiment clarified the anatomical specificity of the effect, showing that the face deficit did not occur when the site of stimulation was moved just 2 centimetres away, to a site that fMRI studies suggest is involved in object (but not face) analysis [12]. Lastly, the authors focused on the timing of the disruptive effect. TMS pulses were delivered over the occipital face area at a range of time points. Remarkably, this produced a deficit only between 60 and 100 milliseconds after the target face appeared. TMS in other time windows ranging up to 250 milliseconds (an aeon in terms of visual face recognition) had no effect.

These results neatly constrain the interpretation of the occipital face area, suggesting it plays a critical early role in the analysis of faces and particularly individual face features. The absence of an effect on the spacing of face parts is notable, given that such 'configural' information is an important part of identifying faces [3]. Thus the occipital face area may be an 'entry point' for face processing, providing an initial but incomplete representation for the benefit of more anterior regions.

The occipital face area has been rather neglected by researchers in favour of its neighbour on the fusiform gyrus. But recent work aimed at identifying the critical site of brain injury for acquired

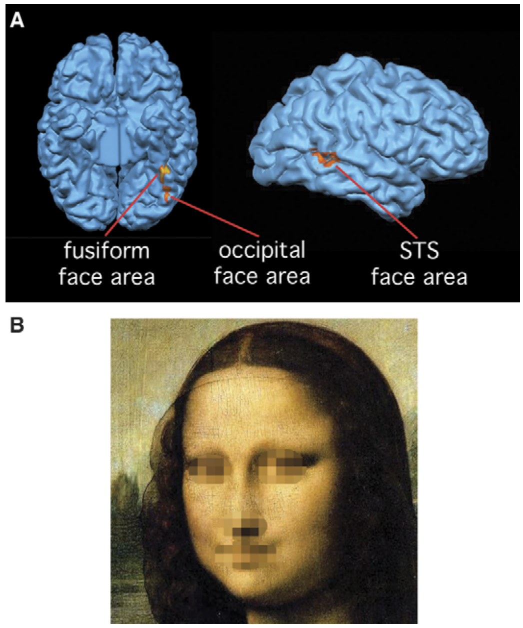

Figure 1. Face perception.

(A) Brain areas implicated in face perception. The rendering on the left is of the brain from underneath, indicating the location of the occipital and fusiform face areas in the right hemisphere. The rendering on the right is a side view of the right hemisphere, showing a face-responsive region in and around a posterior part of the superior temporal sulcus (STS). (B) Disruption of face part perception. This artistic rendering attempts to capture the effect that transcranial magnetic stimulation has when applied to the occipital face area. The quality of visual information about face parts is reduced — perhaps by the introduction of noise into neural activity — while information about the arrangement of these parts into a whole face remains unimpaired.

prosopagnosia suggests that damage to the occipital face area can lead to profound face-perception problems [13,14] and can have a remote impact, for example, on activity in the fusiform face area [15]. The latter finding, in conjunction with the results of Pitcher *et al.* [10], suggests a new approach to understanding the interactions among face-selective brain regions. This is important, because while it has been argued that these areas form a face perception network [16], the direct evidence for their interaction is scarce.

The combination of TMS with fMRI may prove key to exploring these interactions. How does face-related brain activity, as measured with fMRI, change if a part of the face network is disrupted with TMS? If other areas rely on the intact outputs of the occipital face area in order to make sense of faces, then their activity should change when that region is disrupted. This could be reflected in gross changes — such as a lower ratio of face:non-face response in a particular area. Subtler effects may be more likely. For example, the fusiform face area appears to represent the identity of faces [17] in a perceptual 'space' centred around a prototypical 'average' face [18]. Would this subtle encoding of face information, as revealed by fMRI, be compromised if the occipital face area were disrupted? Furthermore, while the fusiform face area is out of reach of direct TMS effects, a similar general approach might test the consequences of disrupting the superior temporal sulcus [19]. Studies of this type promise to provide direct, causal evidence on how different brain areas contribute to the task of making sense of faces, and on how they interact.

Face perception fascinates the neuroscientist and layperson alike, and it is a safe bet that this fascination will continue. The last few decades have seen enormous progress in understanding how the brain makes sense of the face. The study by Pitcher *et al.* [10] adds key new evidence to the picture, and points the way to promising avenues for future research.

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